

CLAIMS

We claim:

1. A biaxially oriented polyester film produced from a polyester comprising:
 - (1) diacid residues comprising at least 90 mole percent of terephthalic acid residues, naphthalenedicarboxylic acid residues or combinations thereof; and
 - (2) diol residues comprising at least 90 mole percent of 1,4-cyclohexanedimethanol residues; wherein the polyester comprises a total of 100 mole percent diacid residues and a total of 100 mole percent diol residues;wherein a film of the polyester is stretched or oriented at stretch ratios and stretch temperatures that satisfy the equation $(27 \cdot R) - (1.3 \cdot (T - T_g)) \geq 27$, where T is the average of the machine and transverse direction stretch temperatures in degrees Celsius, T_g is the glass transition temperature of the polymer film in degrees Celsius and R is the average of the machine and transverse direction stretch ratios and the stretched film is subsequently heat-set at an actual film temperature of from 260°C to T_m , wherein T_m is the melting point of the polyester as measured by differential scanning calorimetry (DSC), while maintaining the dimensions of the stretched film.
2. The biaxially oriented polyester film of Claim 1 wherein the biaxially oriented and heat-set polyester film undergoes not more than 3% shrinkage when immersed for 10 seconds in a solder bath preheated to 260°C and exhibits a coefficient of thermal expansion value of 10-85 ppm/°C, when measured between 120 and 150°C.
3. The biaxially oriented polyester film of Claim 2 wherein the biaxially oriented and heat-set polyester film exhibits a coefficient of thermal expansion value of 10-42 ppm/°C, when measured between 25 and 90°C.
4. The biaxially oriented polyester film of Claims 1 or 2 wherein the 1,4-cyclohexanedimethanol residues have a trans isomer content in the range of about 60 to about 100%.

5. The biaxially oriented polyester film of Claims 1 or 2 wherein the 1,4-cyclohexanedimethanol residues have a trans isomer content in the range of about 60 to about 80%.
6. The biaxially oriented polyester film of Claims 1 or 2 wherein the diacid residues comprise at least 90 mole percent of terephthalic acid residues.
7. A biaxially oriented polyester film according to Claim 1 wherein the polyester has a melting point of at least 270°C as measured by differential scanning calorimetry (DSC), and an inherent viscosity of 0.4 to 1.2 as measured at 25°C using 0.50 gram of polymer per 100 mL of a solvent composed of 60 weight percent phenol and 40 weight percent tetrachloroethane according to ASTM method D2857-95 comprises:
 - (1) diacid residues comprising at least 97 mole percent of terephthalic acid residues, naphthalenedicarboxylic acid residues or combinations thereof; and
 - (2) diol residues comprising at least 97 mole percent of 1,4-cyclohexanedimethanol residues.
8. The biaxially oriented polyester film according to Claim 7 wherein the polyester has an inherent viscosity of 0.5 to 1.1 as measured at 25°C using 0.50 gram of polymer per 100 mL of a solvent composed of 60 weight percent phenol and 40 weight percent tetrachloroethane according to ASTM method D2857-95
9. A biaxially oriented polyester film according to Claim 7 wherein the polyester has a melting point of 270 to 330°C as measured by differential scanning calorimetry (DSC), and an inherent viscosity of 0.5 to 1.1 as measured at 25°C using 0.50 gram of polymer per 100 mL of a solvent composed of 60 weight percent phenol and 40 weight percent tetrachloroethane according to ASTM method D2857-95 and the film of the polyester is stretched at stretch ratios and stretch temperatures that satisfy the equation $(27 \cdot R) - (1.3 \cdot (T - T_g)) \geq 27$, wherein T is the average of the machine and transverse direction stretch temperatures in degrees Celsius, T_g is the glass

transition temperature of the polymer film in degrees Celsius and R is the average of the machine and transverse direction stretch ratios.

10. The biaxially oriented polyester film of Claim 7 wherein said film undergoes not more than 3% shrinkage when immersed for 10 seconds in a solder bath preheated to 260°C and exhibits a coefficient of thermal expansion value of 10-85 ppm/°C, when measured between 120 and 150°C.

11. The biaxially oriented polyester film of Claim 10 wherein the biaxially oriented and heat-set polyester film exhibits a coefficient of thermal expansion value of 10-42 ppm/°C, when measured between 25 and 90°C.

12. The biaxially oriented polyester film of Claims 7 or 10 wherein the 1,4-cyclohexanedimethanol residues have a trans isomer content in the range of about 60 to about 100%.

13. The biaxially oriented polyester film of Claims 7 or 10 wherein the 1,4-cyclohexanedimethanol residues have a trans isomer content in the range of about 60 to about 80%.

14. The biaxially oriented polyester film of Claims 7 or 10 wherein the diacid residues comprise at least 90 mole percent of terephthalic acid residues.

15. A biaxially oriented polyester film produced from a polyester comprising:

- (1) diacid residues comprising at least 90 mole percent of terephthalic acid residues, naphthalenedicarboxylic acid residues or combinations thereof; and
- (2) diol residues comprising at least 90 mole percent of 1,4-cyclohexanedimethanol residues; wherein the polyester comprises a total of 100 mole percent diacid residues and a total of 100 mole percent diol residues;

wherein a film of the polyester is stretched or oriented at stretch ratios and stretch temperatures that satisfy the equation $(27 \cdot R) - (1.3 \cdot (T - T_g)) \geq 27$, where T is the average of the machine and transverse direction stretch temperatures in degrees Celsius, T_g is the glass transition temperature of the polymer film in degrees Celsius and R is the average of the machine and transverse direction stretch ratios and the stretched film is subsequently heat-set at an actual film temperature of from 260°C to T_m , wherein T_m is the melting point of the polyester as measured by differential scanning calorimetry (DSC), while maintaining the dimensions of the stretched film, and wherein the biaxially oriented and heat-set polyester film undergoes not more than 3% shrinkage when immersed for 10 seconds in a solder bath preheated to 260°C and exhibits a coefficient of thermal expansion value of 10-85 ppm/°C, when measured between 120 and 150°C.

16. The biaxially oriented polyester film of Claim 15 wherein the biaxially oriented and heat-set polyester film undergoes not more than 3% shrinkage when immersed for 10 seconds in a solder bath preheated to 260°C and exhibits a coefficient of thermal expansion value of value of 10-42 ppm/°C, when measured between 25 and 90°C.

17. A biaxially oriented polyester film according to Claim 15 wherein the stretched film is heat-set at an actual film temperature of from 260°C to T_m , wherein T_m is the melting point of the polyester as measured by differential scanning calorimetry (DSC), for a period of time of 1 to 120 seconds while maintaining the dimensions of the stretched film.

18. A biaxially oriented polyester film according to Claim 17 wherein the film of the polyester is sequentially stretched in the machine and the transverse directions and the stretched film is heat-set at an actual film temperature of from 260°C to T_m , wherein T_m is the melting point of the polyester as measured by differential scanning

calorimetry (DSC), for a period of time of 1 to 120 seconds while maintaining the dimensions of the stretched film.

19. A biaxially oriented polyester film according to Claim 17 wherein the film of the polyester is simultaneously stretched in the machine and the transverse directions and the stretched film is heat-set at an actual film temperature of from 260°C to T_m , wherein T_m is the melting point of the polymer as measured by differential scanning calorimetry (DSC), for a period of time of 1 to 120 seconds while maintaining the dimensions of the stretched film.

20. A thermoplastic article obtained by applying heat and pressure to one or more laminates wherein at least one of said laminates comprises in order:

I. a thermally curable adhesive; and

II. a biaxially oriented and heat-set polyester film produced from a polyester comprising:

(1) diacid residues comprising at least 90 mole percent of terephthalic acid residues, naphthalenedicarboxylic acid residues or combinations thereof; and

(2) diol residues comprising at least 90 mole percent of 1,4-cyclohexanedimethanol residues; wherein the polyester comprises a total of 100 mole percent diacid residues and a total of 100 mole percent diol residues;

wherein said polyester film is stretched or oriented at stretch ratios and stretch temperatures that satisfy the equation $(27 \cdot R) - (1.3 \cdot (T - T_g)) \geq 27$, where T is the average of the machine and transverse direction stretch temperatures in degrees Celsius, T_g is the glass transition temperature of the polymer film in degrees Celsius and R is the average of the machine and transverse direction stretch ratios and the stretched film is subsequently heat-set at an actual film temperature of from 260°C to T_m , wherein T_m is the melting point of the polymer as measured by differential scanning calorimetry (DSC), while maintaining the dimensions of the stretched film.

21. A thermoplastic article obtained by applying heat and pressure to one or more laminates wherein at least one of said laminates comprises in order:

- I. a copper layer;
- II. a thermally curable adhesive; and
- III. a biaxially oriented and heat-set polyester film produced from a polyester comprising:
 - (1) diacid residues comprising at least 90 mole percent of terephthalic acid residues, naphthalenedicarboxylic acid residues or combinations thereof; and
 - (2) diol residues comprising at least 90 mole percent of 1,4-cyclohexanedimethanol residues; wherein the polyester comprises a total of 100 mole percent diacid residues and a total of 100 mole percent diol residues;

wherein said polyester film is stretched or oriented at stretch ratios and stretch temperatures that satisfy the equation $(27 \cdot R) - (1.3 \cdot (T - T_g)) \geq 27$, where T is the average of the machine and transverse direction stretch temperatures in degrees Celsius, T_g is the glass transition temperature of the polymer film in degrees Celsius and R is the average of the machine and transverse direction stretch ratios and the stretched film is subsequently heat-set at an actual film temperature of from 260°C to T_m , wherein T_m is the melting point of the polymer as measured by differential scanning calorimetry (DSC), while maintaining the dimensions of the stretched film.

22. The thermoplastic article of Claim 21 wherein the at least one of said laminates comprises, in order:

- I. a copper layer having a thickness of 17 to 140 microns;
- II. a thermally curable adhesive; and
- III. a biaxially oriented and heat-set polyester film of Claim 12 wherein the polyester has a melting point of at least 270°C as measured by differential scanning calorimetry (DSC), and an inherent viscosity of 0.4 to 1.2 as measured at 25°C using 0.50 gram of polymer per 100 mL of a solvent composed of 60 weight percent phenol and 40 weight percent tetrachloroethane according to ASTM method D2857-95 comprises:
 - (1) diacid residues comprising at least 97 mole percent of terephthalic acid residues, naphthalenedicarboxylic acid residues or combinations thereof; and

(2) diol residues comprising at least 97 mole percent of 1,4-cyclohexanedimethanol residues.

23. A process for the preparation of a thermoplastic article wherein heat and pressure are applied to one or more laminates, wherein at least one of said laminates comprises, in order:

- (a) a copper layer;
- (b) a thermally curable adhesive; and
- (c) a biaxially oriented and heat-set polyester film produced from a polyester

comprising:

(1) diacid residues comprising at least 90 mole percent of terephthalic acid residues, naphthalenedicarboxylic acid residues or combinations thereof; and

(2) diol residues comprising at least 90 mole percent of 1,4-cyclohexanedimethanol residues; wherein the polyester comprises a total of 100 mole percent diacid residues and a total of 100 mole percent diol residues;

wherein said polyester film is stretched or oriented at stretch ratios and stretch temperatures that satisfy the equation $(27 \cdot R) - (1.3 \cdot (T - T_g)) \geq 27$, where T is the average of the machine and transverse direction stretch temperatures in degrees Celsius, T_g is the glass transition temperature of the polymer film in degrees Celsius and R is the average of the machine and transverse direction stretch ratios and the stretched film is subsequently heat-set at an actual film temperature of from 260°C to T_m , wherein T_m is the melting point of said polyester as measured by differential scanning calorimetry (DSC), while maintaining the dimensions of the stretched film., and

wherein said heat is applied to said laminate at a temperature of about 120 to 180°C under pressure for a period of time sufficient to cure the thermally curable adhesive.

24. A flexible electronic circuit board comprising at least one biaxially oriented polyester film produced from a polyester comprising:

- (1) diacid residues comprising at least 90 mole percent of terephthalic acid residues, naphthalenedicarboxylic acid residues or combinations thereof; and
- (2) diol residues comprising at least 90 mole percent of 1,4-cyclohexanedimethanol residues; wherein the polyester comprises a total of 100 mole percent diacid residues and a total of 100 mole percent diol residues;

wherein a film of the polyester is stretched or oriented at stretch ratios and stretch temperatures that satisfy the equation $(27 \cdot R) - (1.3 \cdot (T - T_g)) \geq 27$, where T is the average of the machine and transverse direction stretch temperatures in degrees Celsius, T_g is the glass transition temperature of the polymer film in degrees Celsius and R is the average of the machine and transverse direction stretch ratios and the stretched film is heat-set at an actual film temperature of from 260°C to T_m, wherein T_m is the melting point of the polyester as measured by differential scanning calorimetry (DSC), while maintaining the dimensions of the stretched film.

25. The flexible electronic circuit board of Claim 24 wherein the biaxially oriented and heat-set polyester film undergoes not more than 3% shrinkage when immersed for 10 seconds in a solder bath preheated to 260°C and exhibits a coefficient of thermal expansion value of 10-85 ppm/°C, when measured between 120 and 150°C.

26. The flexible electronic circuit board of Claim 25 wherein the biaxially oriented and heat-set polyester film of Claim 15 exhibits a coefficient of thermal expansion value of 10-42 ppm/°C, when measured between 25 and 90°C.

27. The flexible electronic circuit board of Claim 24 wherein said polyester film comprises at least one polyester having a melting point of at least 270°C as measured by differential scanning calorimetry (DSC) and an inherent viscosity of 0.4 to 1.2 as measured at 25°C using 0.50 gram of polymer per 100 mL of a solvent composed of 60 weight percent phenol and 40 weight percent tetrachloroethane according to ASTM method D2857-95 comprises:

- (1) diacid residues comprising at least 97 mole percent of terephthalic acid residues, naphthalenedicarboxylic acid residues or combinations thereof; and
- (2) diol residues comprising at least 97 mole percent of 1,4-cyclohexanedimethanol residues.

28. The flexible electronic circuit board of Claim 24 comprising a thermoplastic article obtained by applying heat and pressure to one or more laminates wherein at least one of said laminates comprises in order:

- I. a copper layer;
- II. a thermally curable adhesive; and
- III. a biaxially oriented and heat-set polyester film produced from a polyester comprising:
 - (1) diacid residues comprising at least 90 mole percent of terephthalic acid residues, naphthalenedicarboxylic acid residues or combinations thereof; and
 - (2) diol residues comprising at least 90 mole percent of 1,4-cyclohexanedimethanol residues; wherein the polyester comprises a total of 100 mole percent diacid residues and a total of 100 mole percent diol residues;

wherein said polyester film is stretched or oriented at stretch ratios and stretch temperatures that satisfy the equation $(27 \cdot R) - (1.3 \cdot (T - T_g)) \geq 27$, where T is the average of the machine and transverse direction stretch temperatures in degrees Celsius, T_g is the glass transition temperature of the polymer film in degrees Celsius and R is the average of the machine and transverse direction stretch ratios and the stretched film is subsequently heat-set at an actual film temperature of from 260°C to T_m , wherein T_m is the melting point of the polymer as measured by differential scanning calorimetry (DSC), while maintaining the dimensions of the stretched film.

29. A biaxially oriented polyester film produced from a polyester comprising:

- (1) diacid residues comprising at least 90 mole percent of terephthalic acid residues, naphthalenedicarboxylic acid residues or combinations thereof; and

- (2) diol residues comprising at least 90 mole percent of 1,4-cyclohexanedimethanol residues; wherein the polyester comprises a total of 100 mole percent diacid residues and a total of 100 mole percent diol residues;

wherein said polyester film undergoes not more than 3% shrinkage when immersed for 10 seconds in a solder bath preheated to 260°C and exhibits a coefficient of thermal expansion value of 10-85 ppm/°C, when measured between 120 and 150°C.

30. The biaxially oriented polyester of Claim 29 wherein the biaxially oriented and heat-set polyester film exhibits a coefficient of thermal expansion value of 10-42 ppm/°C, when measured between 25 and 90°C.

31. A biaxially oriented polyester film according to Claim 29 wherein the polyester has a melting point of at least 270°C as measured by differential scanning calorimetry (DSC), and an inherent viscosity of 0.4 to 1.2 as measured at 25°C using 0.50 gram of polymer per 100 mL of a solvent composed of 60 weight percent phenol and 40 weight percent tetrachloroethane according to ASTM method D2857-95 comprises:

- (1) diacid residues comprising at least 97 mole percent of terephthalic acid residues, naphthalenedicarboxylic acid residues or combinations thereof; and
(2) diol residues comprising at least 97 mole percent of 1,4-cyclohexanedimethanol residues.

32. The biaxially oriented polyester film according to Claim 29 wherein the polyester has an inherent viscosity of 0.5 to 1.1 as measured at 25°C using 0.50 gram of polymer per 100 mL of a solvent composed of 60 weight percent phenol and 40 weight percent tetrachloroethane according to ASTM method D2857-95

33. A biaxially oriented polyester film according to Claim 31 wherein the polyester has a melting point of 270 to 330°C as measured by differential scanning calorimetry (DSC), and an inherent viscosity of 0.5 to 1.1 as measured at 25°C using 0.50 gram of polymer per 100 mL of a solvent composed of 60 weight percent phenol and 40

weight percent tetrachloroethane according to ASTM method D2857-95 and the film of the polyester is stretched at stretch ratios and stretch temperatures that satisfy the equation $(27 \cdot R) - (1.3 \cdot (T - T_g)) \geq 27$, wherein T is the average of the machine and transverse direction stretch temperatures in degrees Celsius, T_g is the glass transition temperature of the polymer film in degrees Celsius and R is the average of the machine and transverse direction stretch ratios.

34. A biaxially oriented polyester film produced from a polyester comprising:

- (1) diacid residues comprising at least 90 mole percent of terephthalic acid residues, naphthalenedicarboxylic acid residues or combinations thereof; and
- (2) diol residues comprising at least 90 mole percent of 1,4-cyclohexanedimethanol residues; wherein the polyester comprises a total of 100 mole percent diacid residues and a total of 100 mole percent diol residues;

wherein a film of the polyester is stretched or oriented at stretch ratios and stretch temperatures that satisfy the equation $(27 \cdot R) - (1.3 \cdot (T - T_g)) \geq 27$, where T is the average of the machine and transverse direction stretch temperatures in degrees Celsius, T_g is the glass transition temperature of the polymer film in degrees Celsius and R is the average of the machine and transverse direction stretch ratios and the stretched film is subsequently heat-set at an actual film temperature of from 260°C to T_m , wherein T_m is the melting point of the polyester as measured by differential scanning calorimetry (DSC), while maintaining the dimensions of the stretched film, and wherein the biaxially oriented and heat-set polyester film undergoes not more than 3% shrinkage when immersed for 10 seconds in a solder bath preheated to 260°C and exhibits a coefficient of thermal expansion value of 10-85 ppm/°C, when measured between 120 and 150°C.

35. The biaxially oriented polyester film of Claim 34 wherein the biaxially oriented and heat-set polyester film undergoes not more than 3% shrinkage when immersed for 10 seconds in a solder bath preheated to 260°C and exhibits a coefficient of

thermal expansion value of value of 10-42 ppm/°C, when measured between 25 and 90°C.

36. A biaxially oriented polyester film according to Claim 34 wherein the stretched film is heat-set at an actual film temperature of from 260°C to T_m , wherein T_m is the melting point of the polyester as measured by differential scanning calorimetry (DSC) for a period of time of 1 to 120 seconds while maintaining the dimensions of the stretched film.

37. A biaxially oriented polyester film according to Claim 36 wherein the film of the polyester is sequentially stretched in the machine and the transverse directions and the stretched film is heat-set at an actual film temperature of from 260°C to T_m , wherein T_m is the melting point of the polyester as measured by differential scanning calorimetry (DSC), for a period of time of 1 to 120 seconds while maintaining the dimensions of the stretched film.

38. A biaxially oriented polyester film according to Claim 36 wherein the film of the polyester is simultaneously stretched in the machine and the transverse directions and the stretched film is heat-set at an actual film temperature of from 260°C to T_m , wherein T_m is the melting point of the polymer as measured by differential scanning calorimetry (DSC), for a period of time of 1 to 120 seconds while maintaining the dimensions of the stretched film.

39. A thermoplastic article obtained by applying heat and pressure to one or more laminates wherein at least one of said laminates comprises in order:

- I. at least one thermally curable adhesive; and
- II. at least one biaxially oriented and heat-set polyester film produced from a polyester comprising:

- (1) diacid residues comprising at least 90 mole percent of terephthalic acid residues, naphthalenedicarboxylic acid residues or combinations thereof; and
- (2) diol residues comprising at least 90 mole percent of 1,4-cyclohexanedimethanol residues; wherein the polyester comprises a total of 100 mole percent diacid residues and a total of 100 mole percent diol residues;

wherein said polyester film undergoes not more than 3% shrinkage when immersed for 10 seconds in a solder bath preheated to 260°C and exhibits a coefficient of thermal expansion value of 10-85 ppm/°C, when measured between 120 and 150°C.

40. The thermoplastic article of Claim 39 wherein said polyester comprises:

- (1) diacid residues comprising at least 97 mole percent of terephthalic acid residues, naphthalenedicarboxylic acid residues or combinations thereof; and
- (2) diol residues comprising at least 97 mole percent of 1,4-cyclohexanedimethanol residues; wherein the polyester comprises a total of 100 mole percent diacid residues and a total of 100 mole percent diol residues.

41. The thermoplastic article of Claim 39 wherein said at least one laminate comprises in order:

- I. at least one copper layer
- II. said at least one thermally curable adhesive; and
- III. said at least one biaxially oriented and heat-set polyester film.

42. A flexible electronic circuit board comprising the thermoplastic article of Claim 39.